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(54) **APPARATUS AND METHOD FOR PRINTING ON IRREGULAR SURFACES**

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B25B 11/00 (2006.01)

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(58) **Field of Classification Search** 400/648, 400/656; 271/90, 98, 104, 106, 276; 347/104; 248/363; 269/21; 198/689.1
See application file for complete search history.

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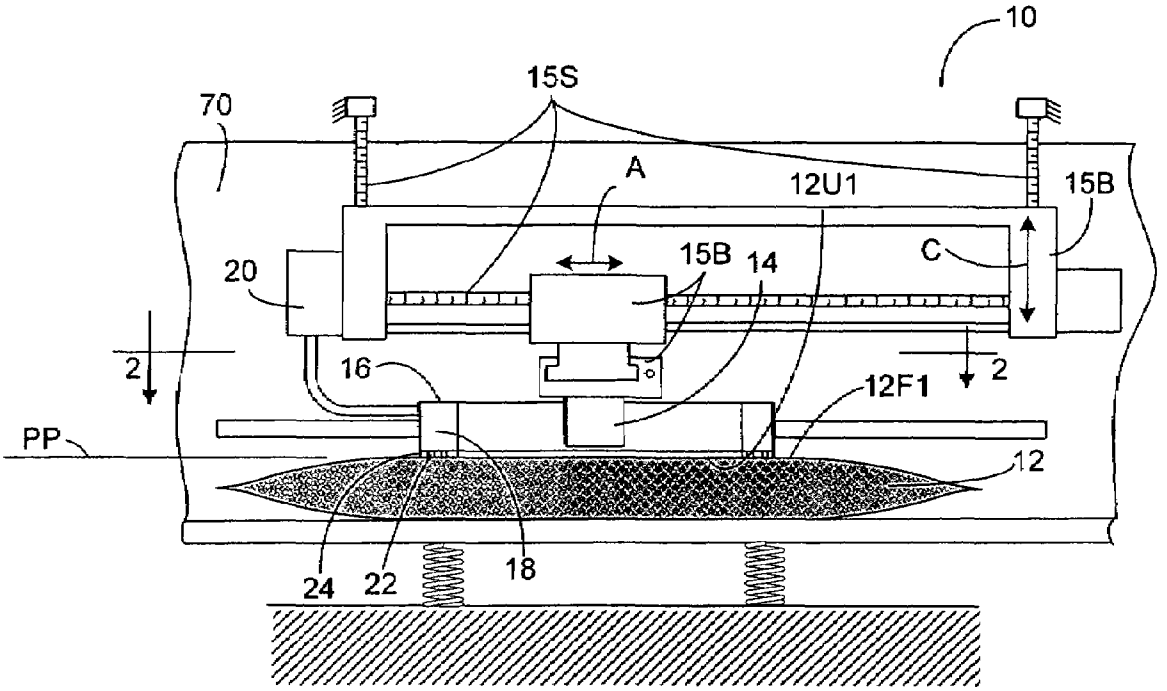
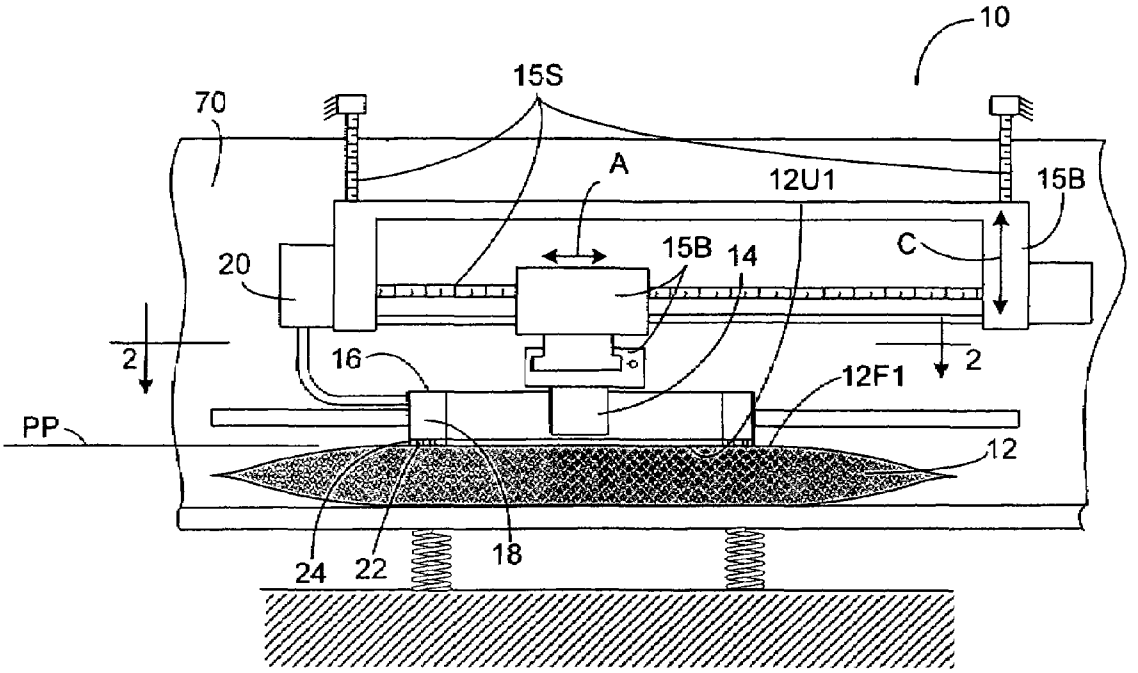
(57) **ABSTRACT**

An apparatus and method for presenting a substrate/print media having favorable surface conditions and optimum spatial orientation for printing purposes. The apparatus/method includes a mechanism for maintaining the substrate/print media in a substantially orthogonal spatial orientation relative to the direction of ink deposition, and a pressurization device for developing a pressure differential across a face surface of the substrate/print media such that positive pressure is applied to a surface opposing the face surface. The pressurization device provides a cushion of air to support the substrate/print media during ink deposition. The apparatus/method may further include a system for transporting the substrate/print media beneath or across a print head assembly for in-line printing on a mailpiece.

22 Claims, 3 Drawing Sheets

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70
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12U1
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12F1
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18

FIG. 1

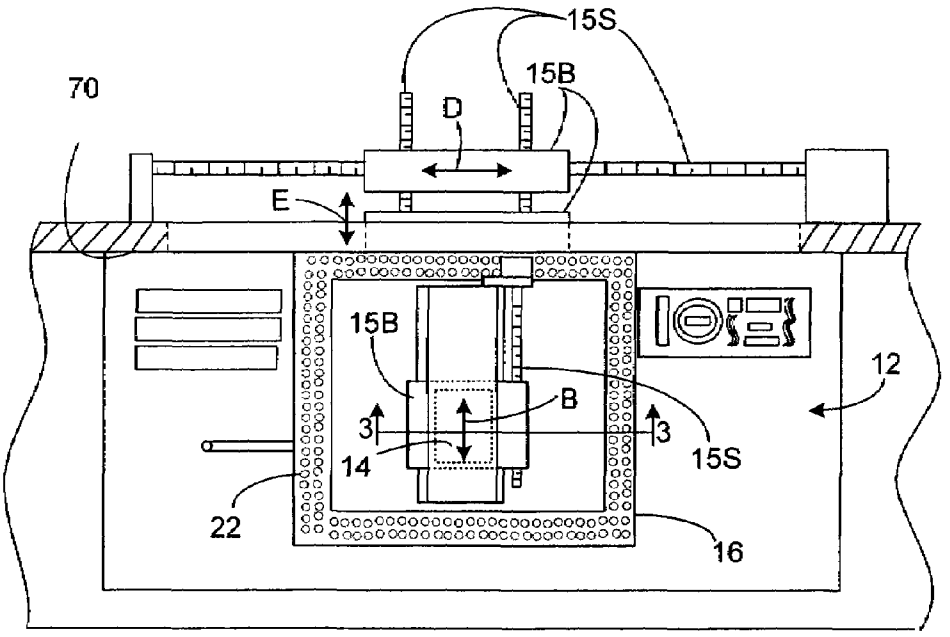
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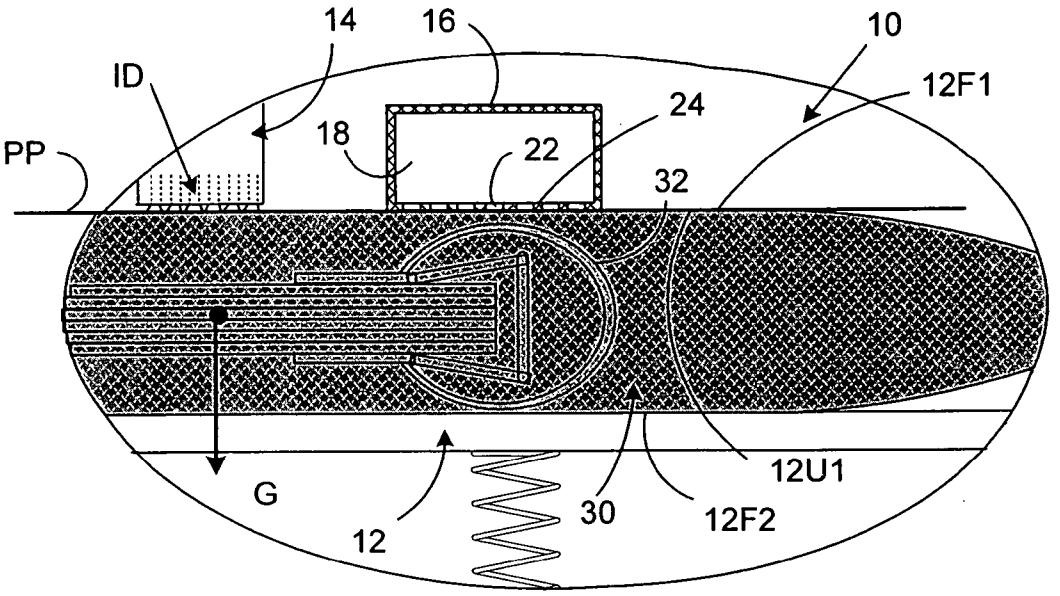
FIG. 2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12F2
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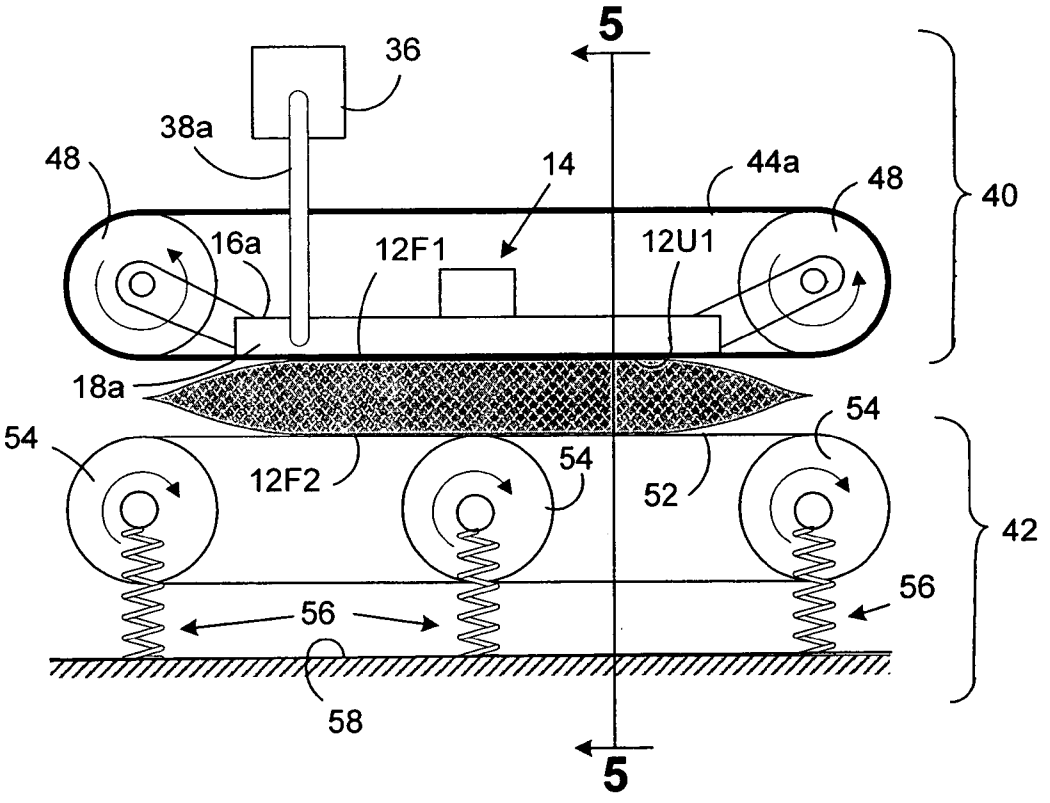
FIG. 3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36
38a
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44a
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12U1
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56
56
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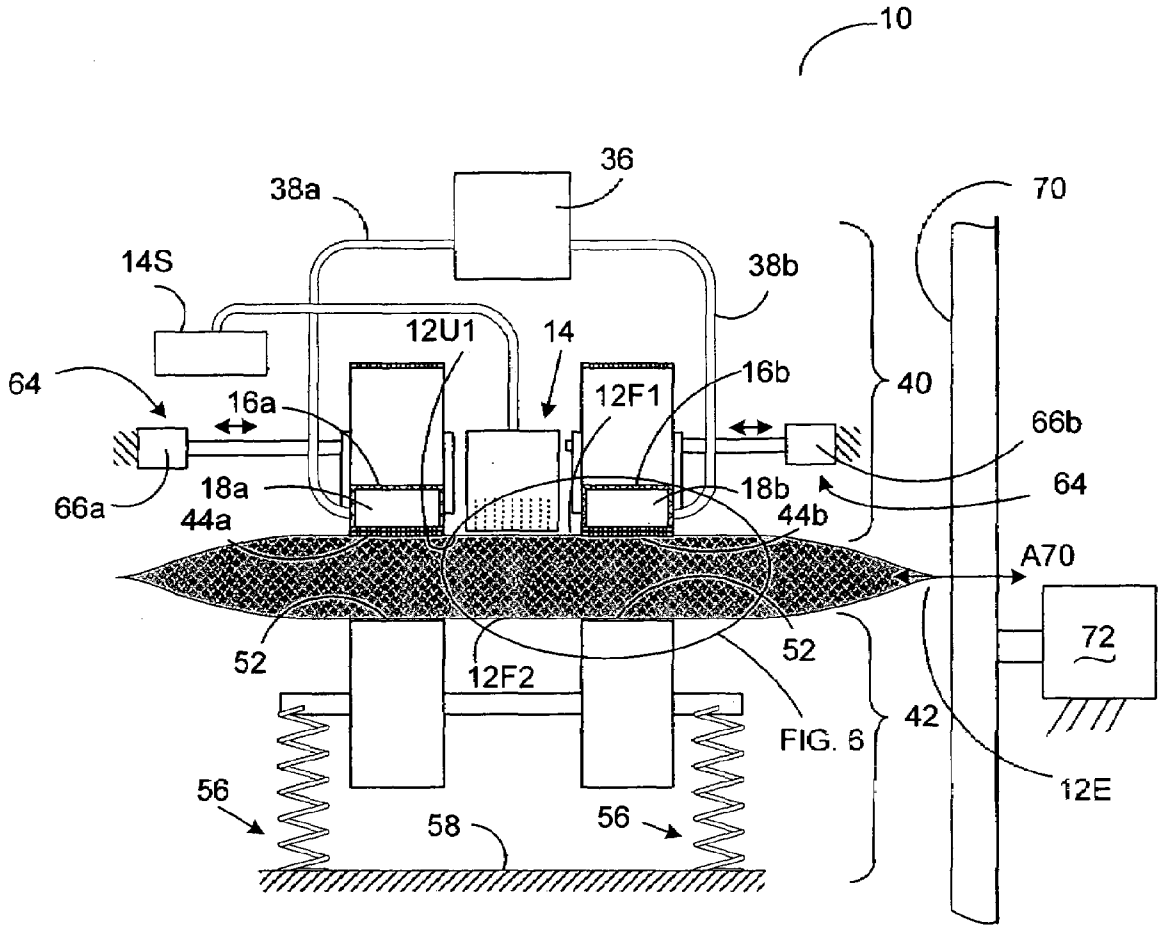
5

FIG. 4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18b
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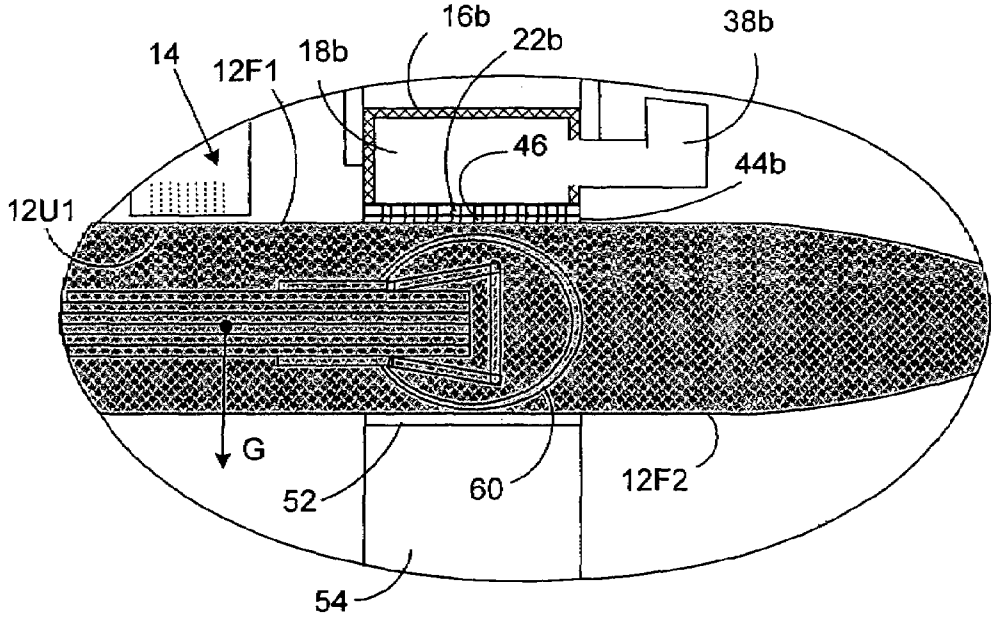
66a
44a
44b
A70
52
52
72
12F2
42
FIG. 6
56
12E
58
56

FIG. 5


16b
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12F1
18b
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44b
12U1
G
52
60
12F2
54

FIG. 6

APPARATUS AND METHOD FOR PRINTING ON IRREGULAR SURFACES

TECHNICAL FIELD

The present invention relates generally to printing devices, and, more particularly, to a new and useful apparatus and method for printing on an irregular surface e.g., a non-planar content surface of a mailpiece, for improved efficacy and readability.

BACKGROUND OF THE INVENTION

Printers, scanners or other printing devices commonly employ a roller/print cylinder to support, or provide a rigid backing structure for the substrate material which carries the printed message/image. The backing structure generally serves to lay the substrate material locally orthogonal and/or at an appropriate distance from the print head/nozzle of the printer. Generally, irregularities in the print surface degrade the efficacy of the printed message/image, i.e., resulting in smearing, smudging, gaps or other undesirable print characteristics.

Envelopes for mailing purposes present unique challenges and anomalies which may be addressed before or after an envelope has been filled or fabricated. It will generally be appreciated that printing prior to envelope filling is most likely to yield a flat/planar surface for optimum printing conditions. That is, an envelope can be viewed as having a print surface comprising multiple layers (a stack having at least two layers when considering the top and bottom face sheets of the envelope) and is best suited for printing before internal contents add other layers or create surface irregularities/anomalies due to an internal staple, clip or binding element.

While certain information such as the mailing address may be pre-printed on an envelope prior to the insertion of mailpiece content material, other information such as the postage indicia should desirably be printed subsequent to mailpiece fabrication. That is, since postage indicia is oftentimes based upon the weight, size and/or thickness of a mailpiece, the postage indicia, which typically includes a combination of graphics and barcode elements, will be printed after the envelope has been filled, sealed and/or weighed. Consequently, the ability to print on an envelope, which may include inserts having staples, clips and/or other binding elements, is necessary, but nonetheless presents challenges in terms of the surface characteristics/conditions which yield optimum print quality.

A need therefore exists for a method and apparatus for printing on an irregular surface while maintaining print efficacy and readability.

SUMMARY OF THE INVENTION

An apparatus/method is provided for printing on the face surface of a substrate material including a print head for depositing ink on the face surface and a means for developing a pressure differential across the face surface. The pressure generating means causes a positive pressure to be developed along the underside of the substrate material, i.e., in a direction opposing the face surface. Specifically, the pressurization means provides a cushion of air to support the substrate/print media during ink deposition and may further include a system for transporting the substrate/print media beneath or across a print head for in-line printing on a mailpiece.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention, and together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention. As shown throughout the drawings, like reference numerals designate like or corresponding parts.

FIG. **1** depicts a side view of an in-line printing apparatus, the apparatus producing an optimum print surface for printing clear, legible text and graphics on the face surface of a substrate material.

FIG. **2** depicts a cross-sectional view taken substantially along line **2-2** of FIG. **1** illustrating a plenum circumscribing the print head, which plenum develops a pressure differential across the face surface of the substrate material.

FIG. **3** depicts an enlarged partial cross-sectional view taken substantially along line **3-3** of FIG. **2** illustrating features of the apparatus which lift the face surface of the substrate material away from underlying structures/elements to present a substantially planar surface for printing.

FIG. **4** depicts an alternate embodiment of the invention including upper and lower conveyors for supporting/moving the mailpiece past an in-line print head and a linear plenum system for developing a pressure differential along the face surface of the substrate material.

FIG. **5** depicts a cross-sectional view taken substantially along line **5-5** of FIG. **4** illustrating a pair of linear plenums disposed to either side of the in-line print head.

FIG. **6** depicts an enlarged view of one of the linear plenums shown in FIG. **5** illustrating a perforated conveyor belt for conveying the substrate material past the in-line print head.

DETAILED DESCRIPTION OF THE DRAWINGS

The present invention is described in the context of an in-line printer assembly for printing text/graphics along a region or zone of a mailpiece as it is conveyed beneath or past a print head assembly. Examples of such regions/zones include those relating to or in-line with the postage indicia, recipient mailing address or sender return address. While the invention is described in the context of a mailpiece, it will be appreciated that the invention is useful for printing on any substrate material/media. Furthermore, the invention has particular application to print media having underlying structures/elements which may cause surface irregularities, i.e., when such structures/elements serve to support the media during ink deposition.

The print head assemblies may include inkjet, bubble-jet or any thermally-activated multi-nozzle array for depositing ink and may be controlled/positioned by any of a variety of processors and conventional printing/computer interface control systems. Inasmuch as such systems and control algorithms are well-known in the art, such elements also will not be described in detail herein. Moreover, similar to other known inkjet printers and print head assemblies, the inkjet printer and print head assembly may employ multiple print heads for delivering and depositing ink on the subject media. Suffice it to say that a variety of print heads may be employed including thermal inkjet heads such as one-half inch (½") and one-sixth inch (⅙") print area heads available from Hewlett-Packard Company under the model designations HP51645A and HP51626A, respectively. Inkjet print heads using other technologies may also be incorporated.

In the broadest sense of the invention, an apparatus and method is provided for presenting a substrate print media in an optimum spatial orientation for printing thereon, comprising: (i) a means for maintaining the substrate media in a

substantially orthogonal spatial orientation relative to the direction of ink deposition, and (ii) a means for developing a pressure differential across a face surface of the media such that positive pressure is applied to a surface opposing the face surface thereby providing a cushion of air to support the substrate media during ink deposition.

Referring to FIGS. **1** and **2**, an apparatus **10** is depicted for supporting and spatially positioning a fabricated mailpiece **12** beneath/past a print head **14** (shown schematically as a simple rectangular block). For the purposes of illustration, it is assumed that the mailpiece **12** is filled with content material, sealed and ready for sorting or subsequent processing, e.g., delivery. The print head **14** may be positioned and manipulated about various axes A, B and C to enable printing in a two dimensional plane, i.e., in a plane PP corresponding to the face surface **12**F**1** of the mailpiece **12**. Likewise, the plenum **16** may be positioned and manipulated about various axes D and E to enable relocation of the plenum relative to the substrate material. The figures schematically show a combination of linear screws **15**S which rotate to drive bearing blocks **15**B linearly along the axes A, B, C, D and E. It will be appreciated, however, that a variety of linear, telescoping or rotary links/elements/tracks may be employed to effect the motion of the print head **14** relative to the underlying mailpiece **12**.

In FIG. **3**, the apparatus **10** is disposed in combination with the print head **14** and includes a plenum **16** defining a channel **18** in fluid communication with a vacuum source **20**. The plenum **16** further includes a plurality of apertures or orifices **22** extending through a wall **24** of the plenum **16** and in fluid communication with the face surface **12**F**1** of the mailpiece **12**. While the described embodiment illustrates a plenum **16** circumscribing the print head **14**, it should be noted that the plenum **16** may be segmented/bifurcated, e.g., having dual segments, and disposed on opposing sides of the print head **14**. Such alternate configurations will be discussed in greater detail below.

The vacuum source **20** (see FIG. **1**) is operative to develop a pressure differential across the face surface **12**F**1** of the mailpiece **12**. Inasmuch as the plenum **16** circumscribes the print head **14**, the plenum **16** develops a bridging effect in the area enveloped by the plenum **16**, and, by virtue of its circumscribed shape, achieves two independent yet complimentary functions. Firstly, the circumscribed plenum **16** causes the face surface **12**F**1** of the mailpiece to span its diameter to present the face surface **12**F**1** of the mailpiece **12** in a substantially planar orientation relative to the print head **14**. Secondly, the face surface **12**F**1** is spatially positioned to be orthogonal relative to the direction ID of ink deposition. As such, the face surface **12**F**1** is supported and stiffened, i.e., made rigid, by the suction developed across the face surface **12**F**1** of the mailpiece **12**. Accordingly, ink may be deposited by the print head **14** on a substantially planar surface with minimal deformation or deflection of the printing surface, i.e., the face surface **12**F**1**.

While the apparatus **10**, i.e., the plenum **16** and vacuum source **20**, function to accurately position and support the face surface **12**F**1** of the mailpiece **12**, the apparatus **10** also functions to lift the face surface **12**F**1** away from any internal structure or mailpiece content **30** which may be contained within the mailpiece **12**. That is, the face surface **12**F**1** is drawn away from internal mailpiece contents **30** which, under the force of gravity, fall away from the underside **12**U**1** of the face surface **12**F**1**. In the illustrated embodiment, the mailpiece content **30** includes a semi-circular binder **32** which has separated from the underside surface **12**U**1** under the force of gravity acting in the direction of arrow G. The apparatus **10**, therefore, eliminates any surface irregularities, e.g., the semi-circular binder **32**, from disrupting the plane of the print surface, i.e., the face surface **12**F**1**. Consequently, the apparatus **10** improves efficacy and readability of messages/images printed by the print head **14**.

In another embodiment of the invention shown in FIGS. **4**, **5** and **6**, the plenum is bifurcated to form pair of linear plenum segments **16***a*, **16***b* disposed to either side of the print head **14**. The plenums segments **16***a*, **16***b* include chambers **18***a*, **18***b*, which are in fluid communication with a common vacuum source **36** (FIGS. **4** & **5**), having conduits **38***a*, **38***b* coupled to each of the chambers **18***a*, **18***b*. Furthermore, the apparatus **10** includes upper and lower conveyors **40**, **42** which function to transport and support the mailpiece **12** as it moves a past the print head **14**, (a system for printing mailpieces commonly known as an in-line print head/printer). More specifically, the upper conveyor **40** includes perforated belts **44***a*, **44***b* disposed between each of the plenum segments **16***a*, **16***b* and the underlying mailpiece **12**. The perforations **46** (See FIG. **6**) in the belts **44***a*, **44***b* provide a fluid path from the face surface **12**F**1** of the mailpiece **12**, to the respective chambers **18***a*, **18***b* via apertures **22***a*, **22***b* formed in each of the segments **16***a*, **16***b*. Moreover the perforations **46** are adapted to provide a substantially constant fluid flow across the belts **44***a*, **44***b*. Such constant fluid flow may be effected by employing rows of perforations each having a substantially rectangular shape (not shown) and, further, being spaced in a staggered configuration. That is, adjacent rows of perforations **46** in the belts **44***a*, **44***b* may be staggered or phased relative to the apertures **22***a*, **22***b* formed in the plenum walls to avoid an alternating alignment/misalignment of the perforations **44***a*, **44***b* with the apertures **22***a*, **22***b* of the plenum segments **16***a*, **16***b*. As a result, the fluid flow will be shared across the perforations **46** rather than opening/closing as a function of a full/partial alignment of the perforations **44***a*, **44***b*, and apertures **22***a*, **22***b*.

The belts **44***a*, **44***b* are driven over a system of drive wheels or pulleys **48** to convey the belts **44***a*, **44***b* linearly past the in-line print head **14** and to each side thereof. The lower conveyor **42** is more conventional inasmuch as the conveyor belts or belt **52** need not include perforations, but need only support and assist the movement of the mailpiece **12**. More specifically, the lower conveyor **42** includes a system of wheels or pulleys **54** which support mailpiece at a height that will allow contents to separate from the surface **12**U**1**. Furthermore, the lower conveyor **42** may lightly support the mailpiece **12** by a suspension system **56**. By "lightly support" is meant that the lower conveyor **42** supports a fraction of the total mailpiece weight. In the illustrated embodiment, the suspension system **56** is shown schematically as a simple coil spring arrangement disposed between each of the wheels **54** and a stationary ground **58**, however, any arrangement which supports less than the total weight of the mailpiece, i.e., while being conveyed along the feed path, may be employed.

Similar to the previously described embodiment, the plenum segments **16***a*, **16***b* develop a bridging effect in the area therebetween. More specifically, the plenum segments **16***a*, **16***b* cause the face surface **12**F**1** to span the distance therebetween and maintain a substantially planar orientation relative to the print head **14**. As such, the face surface **12**F**1** is supported and stiffened, i.e., made rigid, by the suction developed across the face surface **12**F**1** of the mailpiece **12**. Accordingly, ink may be deposited by the print head **14** on a substantially planar surface with minimal deformation or deflection of the printing surface, i.e., the face surface **12**F**1**.

Furthermore, in a manner similar to the annular plenum, the linear plenum segments **16***a*, **16***b* function to lift the face

surface **12**F**1** away from internal structure or mailpiece content material **60** which may be contained within the mailpiece **12**. That is, the face surface **12**F**1** is drawn away from internal mailpiece contents which, under the force of gravity, fall away from the underside **12**U**1** of the face surface **12**F**1**. In the illustrated embodiment, the mailpiece content **60** has fallen away from the underside surface **12**U**1** under the force of gravity acting in the direction of arrow G. The apparatus **10**, therefore, eliminates any surface irregularities disrupting the plane of the print surface, i.e., the face surface **12**F**1**.

In an alternate embodiment of the invention, a mechanism **64** may be employed to increase the separation distance between the plenum segments **16***a*, **16***b* for the purpose of applying a tensile load across the face surface **12**F**1** of the mailpiece **12** during ink deposition. For example, a pair of linear actuators **66***a*, **66***b* may be coupled to each of the plenum segments **16***a*, **16***b*, to separate the segments, including the conveyor belts **44***a*, **44***b*. Consequently, the applied tensile load alleviates or removes any surface irregularities along the face surface **12**F**1**.

Furthermore, while the plenum segments **16***a*, **16***b* may move apart, the segments **16***a*, **16***b* may also move together, i.e., in concert, to change the relative position of the print head **14**, i.e., the position of the print head relative to the face surface **12**F**1** of the mailpiece **12**. Alternatively, a registration wall **70** may be used to locate the mailpiece **12** relative to the print head **14**. More specifically, the registration wall **70** may be positioned by means of a linear actuator **72** connecting to and located opposite an abutting edge **12**E of the mailpiece **12**. As the registration wall **70** translates along axis A**70**, the mailpiece **12** may be shifted in the same direction to change its print position relative to the print head **14**.

Without the further recitation of specific structure to handle the mailpiece, the method is practiced by the steps of (i) supporting the print head relative to the mailpiece such that the face surface thereof is substantially orthogonal to the direction of ink deposition by the print head, (ii) developing a pressure differential across a face surface of the mailpiece such that a positive pressure is applied to a surface opposing the face surface to support the face surface of the mailpiece, and (iii) printing on the face surface of the mailpiece. The various mechanisms for performing these steps may be those previously described or other devices having similar functional characteristics. Furthermore, the mailpiece may be conveyed by an upper and/or lower conveyor in a manner similar to that previously described or via a variety of similar devices.

In summary, an apparatus and method is provided for printing on a substrate material or mailpiece while maintaining a substantially planar orientation during ink deposition. The device may include an annular or linear plenum to develop a pressure differential across the face surface of the substrate material or mailpiece. Alternatively, other mechanisms can be envisioned for developing a pressure differential. For example, a positive pressure may be developed internally of the mailpiece to prevent the content material from creating surface irregularities along the exposed face surface. Similarly, other devices may be employed to draw the face surface away from underlying material so as to avoid disrupting the contour of the print surface. Accordingly, a planar surface contour may be maintained to ensure optimum print quality/readability.

It is to be understood that the present invention is not to be considered as limited to the specific embodiments described above and shown in the accompanying drawings. The illustrations merely show the best mode presently contemplated for carrying out the invention, and which is susceptible to such changes as may be obvious to one skilled in the art. The invention is intended to cover all such variations, modifications and equivalents thereof as may be deemed to be within the scope of the claims appended hereto.

What is claimed is:

1. An apparatus for printing on a face surface of a substrate material, comprising: a print head spatially positioned relative to the substrate material for depositing ink on the face surface, and a means for developing a pressure differential across a face surface of the substrate material such that pressure is applied to an underside surface of the substrate material opposite the face surface and for supporting the substrate material as the print head deposits ink on the face surface, the means for developing a pressure differential further including:

a plenum defining a chamber, the plenum enveloping the print head on at least two sides thereof and having a plurality of apertures through a wall of the plenum, the apertures disposed adjacent the face surface of the substrate material, and a vacuum source disposed in fluid communication with the chamber of the plenum, the vacuum source is operative to develop the pressure differential across the face surface of the substrate material during ink deposition.

2. The apparatus according to claim **1** wherein the plenum circumscribes the print head.

3. The apparatus according to claim **1** wherein the plenum forms linear plenum segments disposed on each side of the print head.

4. The apparatus according to claim **1** further comprising an upper conveyor having a conveyor belt disposed between the plenum and the face surface of the substrate material.

5. The apparatus according to claim **4** wherein the conveyor belt includes a plurality of perforations therein to facilitate the development of a pressure differential across the face surface of the substrate material.

6. The apparatus according to claim **5** wherein the perforations of the belt and apertures of the plenum effect a substantially constant fluid flow as the belt moves across the plenum.

7. The apparatus according to claim **4** further comprising an lower conveyor having a belt contiguous with a lower surface of the substrate material for supporting the same at a predetermined distance relative to the print head.

8. The apparatus according to claim **4** further comprising a registration wall disposed adjacent an edge of the mailpiece and a means for positioning the registration wall to change a position of the print head relative to the face surface of the mailpiece.

9. The apparatus according to claim **4** further comprising an lower conveyor having a belt contiguous with a lower surface of the substrate material for lightly supporting weight of the substrate material.

10. The apparatus according to claim **1** wherein the substrate material defines a mailpiece envelope having first and second face surfaces and content material therebetween, and wherein the plenum develops the pressure differential across one of the face surfaces to separate the content material from the underside thereof thereby obviating surface irregularities during ink deposition.

11. The apparatus according to claim **1** wherein the plenum forms linear plenum segments disposed on each side of the print head and further comprising a means for separating the plenum segments to apply a tensile load across the face surface during ink deposition.

12. An apparatus for printing on a mailpiece having first and second face surfaces and content material therebetween and a print head for depositing ink on a face surface of the mailpiece, comprising:

a device for spatially positioning the print head relative to the substrate material such that the substrate material is substantially orthogonal to a direction of ink deposition by the print head, and

a plenum defining a chamber, the plenum enveloping the print head on at least two sides thereof and having a plurality of apertures through a wall of the plenum, the apertures disposed adjacent the face surface of the substrate material, and

a vacuum source disposed in fluid communication with the chamber of the plenum,

whereby the vacuum source is operative to develop the pressure differential across one of the face surfaces to separate the content material from the underside of the face surface thereby obviating surface irregularities during ink deposition.

13. The apparatus according to claim 12 wherein the plenum circumscribes the print head.

14. The apparatus according to claim 12 wherein the plenum is bifurcated to form linear plenum segments disposed on each side of the print head.

15. The apparatus according to claim 12 further comprising an upper conveyor having a conveyor belt disposed between the plenum and the face surface of the substrate material, the conveyor belt moving the substrate material past the print head during ink deposition.

16. The apparatus according to claim 15 wherein the conveyor belt includes a plurality of perforations therein to facilitate a development of a pressure differential across the face surface of the substrate material.

17. The apparatus according to claim 15 further comprising an lower conveyor having a belt contiguous with a lower surface of the substrate material for supporting a portion of its weight during ink deposition.

18. The apparatus according to claim 12 wherein the plenum forms linear plenum segments disposed on each side of the print head and further comprising a means for separating the plenum segments to apply a tensile load across the face surface during ink deposition.

19. A method for printing on a face surface of a mailpiece by using a print head for depositing ink, the method comprising the steps of:

supporting the print head relative to the mailpiece such that the face surface thereof is substantially orthogonal to a direction of ink deposition by the print head,

developing a pressure differential across a face surface of a substrate material such that a pressure is applied to an underside surface opposite the face surface to support the face surface of the mailpiece during print operations, the pressure differential produced by a plenum defining a chamber, the plenum enveloping the print head on at least two sides thereof and having a plurality of apertures through a wall of the plenum, the apertures disposed adjacent the face surface of the substrate material, and providing a vacuum source disposed in fluid communication with the chamber of the plenum, the vacuum source being operative to develop the pressure differential across the face surface to separate content material from the underside thereof to obviate surface irregularities during ink deposition, and

printing on the face surface of the mailpiece.

20. The method according to claim 19 further including the step of providing an upper conveyor having a conveyor belt disposed between the plenum and the face surface of the substrate material, the conveyor belt moving the substrate material past the print head during ink deposition.

21. The method according to claim 20 wherein the conveyor belt includes a plurality of perforations therein to facilitate a development of a pressure differential across the face surface of the mailpiece.

22. The method according to claim 20 further including the step of providing a lower conveyor having a belt contiguous with a lower surface of the substrate material for supporting a portion of its weight during ink deposition.

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